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EXPERIMENTAL PEDAGOGY IN GERMANY FIFTH ARTICLE

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We were discussing the question of how the daily schedule is to be arranged, and had found that the order of subjects should be determined by the shape of the energy curve. The easier subjects are to be located at the times when the mental energy is falling, the more difficult at the times when it is rising.

In the sense of this requirement, we regard that subject as the most difficult which requires the greatest mental effort in the pupils, that is, which uses up the most mental energy. The question is, then, whether we can measure this mental effort. One such method of measurement is obvious enough. It is based on the self-evident fact that the degrees of subsequent fatigue must correspond exactly to the degrees of intellectual strain. Accordingly, it is sufficient simply to estimate the mental effort of the pupils by the degrees of fatigue which each subject produces. But how are we to estimate the degrees of fatigue? Here arises first the real difficulty, the one principal difficulty of our problem. At first there does not seem to be any difficulty here. For nothing seems simpler than to measure the degrees of fatigue. Are we not familiar with the inhibiting effects of fatigue on the sensory and the motor functions and on the power to do mental work? Should it not be possible to determine easily and with certainty from the magnitude of these effects the magnitude of the causes? Experiment has decided otherwise. We have already had an inkling of the embarrassments lurking here, and shall soon hear still more of them. In fact, it is one of the most difficult tasks of experimental pedagogy to find a trustworthy measure of fatigue.

Not only does the problem of the schedule encounter an apparently insurmountable obstacle in the way of practical experi-

mentation. Not even is its theoretical point of departure sufficiently certain. A second difficulty, in fact, which we slurred over above, meets us at the very outset of our course of thought.

We had been guided by three proportionalities:

a) The mental strain of the children was held to vary according to the difficulty of the subject in which they were instructed. The former was considered proportional to the latter, so that the effort of the pupils would give a measure of the difficulty of the material.

b) The effort of the pupils was supposed to be evinced by the degree of fatigue produced by each subject of instruction. Fatigue and effort being thus in proportion, the former would furnish a measure for the latter.

c) The magnitude of fatigue was assumed to express itself (again, proportionally) in the inhibiting effects which it produced upon the sensory, motor, and intellectual functions, the degree of inhibition measuring the degree of fatigue.

Briefly stated, this is: The fatigue-effect of each study was assumed to measure at once the mental effort of the pupils and the objective difficulty of the material in which they were instructed.

Cogent as this reasoning appears, there is nevertheless an error in the very first step. Is it really the different subjects of instruction which produce the different degrees of fatigue? Is it not rather the different methods of instruction and the different personalities of the instructors? One teacher will teach in a way that bores the pupils without exciting their zeal, their eagerness to learn. Their thoughts wander while he is talking or questioning individuals. A second teacher works with a severe external discipline. By commanding tone and biting sarcasm and unhesitating use of the means of discipline he knows how to intimidate the class, and holds it spell-bound, so that his words are always sure of receiving careful attention. The third teacher understands how to awaken in his pupils delight in the subject, so that the spontaneous attention of interest and not the forced attention of fear follows his questions and explanations.

Whatever the subject may be, the first teacher will fatigue his pupils least, the second, most. The method of the third teacher is the pedagogically and hygienically correct method. His method is pedagogically correct: the pupils learn under him, and they are there to learn. They ought to do mental work so that later on they may be able to accomplish something worth while. Hence their mental energy must not lie fallow, as with the first teacher, but must be put to use. The third teacher's method is hygienically correct. He works without any unnecessary, superfluous expenditure of energy on the part of his pupils. He gets results from their nervous capital, wasting none of it, but securing the largest possible accomplishment with the greatest economy of their strength. The severe teacher, with his corporal's discipline, forces the pupils to the greatest effort of the will and fatigues them most. That is, the severe teacher works with their voluntary, forced attention, instead of using the involuntary attention which flows on of itself. Recall for a moment a comparison which we have already used. We compared mental energy to the current of a brook which must set in motion the logical mill of that co-operation of perception, memory, and judgment which instruction is to produce in the mind of the pupil. Now voluntary attention, to carry out the comparison, is like water which has been pumped up, which first had to be artificially raised against the resistance of gravity, in order to be able to flow in the desired course. Voluntary attention may be called artificial attention, attention meeting with resistance.

Involuntary attention, on the other hand, is like the natural descent of the water—or, in this case, of mental energy—in that it flows on entirely of itself. What then is the natural descent of attention—where does it work easily, freely, and certainly? It does this where something pleases us. All pleasurable stimulations are like wells and channels wherein the springs of our mental energy burst forth of their own accord, without having to overcome resistance. Even popular speech is aware of this: “*Lust und Liebe zum Dinge macht Mühe und Arbeit geringe.*”

The attention which streams out of these wells and flows in these channels we call interest. Interest is involuntary attention, it is mental energy in its natural descent, that is, in so far as it is guided by some pleasurable stimulation. The teacher who works with it will get a maximum of success with a minimum of effort, while he who works with voluntary attention will attain only a minimum of success with a maximum of effort.

Let us return now to our starting-point. The problem of setting up a wise schedule of studies was reduced to the determination of the respective difficulty of the subjects of instruction by the degree in which they produce fatigue. But we found at once *a priori* that it is never the subject alone which produces the fatigue, but always also the manner of teaching. Hence to be able to compare the various subjects according to their fatigue-effects we must think of them as taught by the same teacher and according to the same method, that is to say, reasonably, according to the method which works with the spontaneous interest of the pupils. Still another precaution would be requisite: that the lessons whose fatigue values are to be compared be put at the same hour of the day. That is necessary to eliminate the effects of the daily variations of the mental energy.

All this is far from sufficient to enable us to judge from the phenomena of fatigue the objective difficulty of the subjects of instruction. For even if the same teacher instructs the same pupils at the same hour of the day in different subjects, the difference in the material difficulty of the subjects is by no means necessarily reflected in the difference of the fatigue-effects. The peculiar nature of each subject conditions the details of method in the instruction. Such details cannot be compared; and thus the varying way in which they strain the attention affects in a manner which we cannot compute the result which the subject itself produces on the mind of the child, according as it is more abstract or more concrete, and employs more analytic or synthetic thinking, intuition or observation, comparative-causal or demonstrative inference.

The attempt to infer the comparative difficulty of the subjects of instruction from their fatigue-effects is burdened with another and graver objection, which goes to the heart of the whole question. We know how awkwardly the beginner works, how disagreeable the first steps are to him, how little he can succeed in unifying the single performances of which the action consists. That holds of the acquirement of bodily skill, and quite as much of the attainment of all mental ability. Only recently Meumann has shown in instructive experimental investigations that even so comparatively simple a process as mechanical memorizing is at first performed with much unnecessary expenditure of energy; for example, the position of the body manifests the tension of quite unnecessary groups of muscles. Moreover, the learner uses regularly at first the more complicated of the means of learning placed at his disposal by his psychological habit (the predominantly visual or acoustic or motor nature of the material of his ideas, the rhythm of his activity), and comes to know the simpler and more suitable only by use, while at the same time there takes place a certain advantageous mechanization.

So for every occupation the right inner arrangement—a certain equilibrium of the suitable means, a certain mechanism of the fundamental activities, on the basis of which the consciousness becomes free for wider, higher performance—must first become familiar. Every beginner at first wastes his powers. He applies some which do not help him, and uses others at the wrong place.

The same is true of the pupil. It is not merely that unnecessary strain is often imposed upon him from without, by the teacher, as is the case when he is taught according to a false method. Superfluous expenditures of force are imposed upon him also from within, in the beginning of every study. They arise from the natural unskilfulness with which he at first takes hold of the unfamiliar matters. The inexperienced pupil proceeds, from the standpoint of energy, uneconomically with his means, and is punished by overgreat fatigue.

This subjective fatigue-component, produced by the pupil's

lack of skill, is of course extremely variable. It must be disposed of first if we wish to determine what may be called the objective energy-equivalent of the work belonging to the various subjects as such, according to their intrinsic quality. Hence it seems obvious that we are to investigate the fatigue-effect of the various subjects only on such pupils as are already to some extent familiar with the scientific activity required of them. We had earlier made the requirement of the same time of day and the same teacher in order to make the difficulty of the school subjects comparable. Now the further requirement appears necessary, that the pupils by whose fatigue we wish to measure the difficulty of the subjects must have had as much practice as possible in each.

Necessary as this requirement is in the interest of exact measurements, still it is contrary to the sense of the experiment. For in every period of scientific instruction the pupil is to learn, i. e., on the basis of processes which he understands he is to be led over to processes which he has not mastered. It is not a static but a dynamic element, not a completed but a growing mastery of the material, which conditions the energy-equivalent of the work of a lesson. How can this imponderable thing be compared in the different subjects! Even if we ventured to say that the pupils are exactly as well trained in one subject, say Latin, as in another, say mathematics, can the advance which the next mathematical lesson is to produce in mathematical knowledge, and for the attainment of which the mental energy of the pupils is demanded, be thought in any way comparable with an analogous advance in Latin?

Questions and doubts of the sort mentioned have been too little regarded in the experimental investigations by which it has been sought to measure the relative difficulty of the various subjects of instruction. It has not been determined whether the pupils were subjected to comparable processes of instruction and to comparable processes of learning. On this account all the numbers which have been stumbled upon have no value for comparison, even if the methods used had been unobjection-

able. Thus, for instance, Ludwig Wagner¹ reports that he has found the following fatigue-values of the various subjects: Mathematics, 100; Latin, 91; Greek, 90; gymnastics, 90; history, 85; geography, 85; computing, 82; French, 82; German, 82; nature-study, 80; drawing, 77; religion, 77.

Such a graded scale, comparing the difficulty of the various subjects of instruction in the measure of fatigue, is very interesting. But, according to the preceding, numerical values such as these must be regarded with extreme skepticism. They give a flattering presentment of a comparability of the subjects of instruction from which in reality we are very far distant. Moreover, L. Wagner had already indicated the one point which we have emphasized above, that "the personality of the teacher counts for incomparably more than the material."

Our criticism of the attempts to read off the difficulty of the material of instruction from the phenomena of fatigue is not yet ended. It is continued and strengthened if we turn our attention to the methodology of measuring fatigue. Our previous result ran: The fatigue of the pupils does not measure what it is supposed to measure, namely, the intrinsic difficulty of each subject. Now it will appear (or rather, it has long been known to experts) that fatigue itself is not uniquely measurable. At least the methods hitherto used do not suffice to measure it.

We have already met with one such method. It is the psychological method of measurement, as we may call it in distinction from the other, the physiological, methods. It consists in having the pupils prepare some one sort of easy "test-work" just before and just after the "fatigue-work" (the instruction in the subjects to be compared, as Latin, mathematics, etc.). The degree of fatigue, it is expected, must be shown exactly by the degree in which the succeeding "test-work" is poorer than the preceding.

Kraepelin believes that the continued addition of one place numbers is to be recommended as a "test-work." That is the

¹ Ludwig Wagner, "Unterricht und Ermüdung," *Sammlung von Abhandlungen aus dem Gebiete der pädagogischen Psychologie und Physiologie*, herausgegeben von H. Schiller und Th. Ziehen, Berlin, 1898.

process by which he got his beautiful conclusions concerning the work curve, except that the test is limited to five minutes. Otherwise, indeed, it would produce new fatigue, instead of measuring what is already present. For the result, as in the case of the experiments on the work curve, it is not the exceptional errors in addition which may have occurred but the quantity of numbers added which is to decide. It is not then the reliability, but the rapidity, of the performance that is considered decisive by the Munich psychologist. This, because in such easy computations as the above the errors made are negligible (for adults, about 0.1 per cent.), but above all because the correctness of the additions is proved to depend only on the speed of the work, not on the fatigue. That is, if the subject of the experiment computes more slowly he makes fewer mistakes, and still it is precisely in the retardation of the process that his fatigue is shown.²

It is not easy to carry out such tests with the necessary accuracy. In such short performances as adding for five minutes, among other things, the impulse of the will to take up the activity is manifested in the beginning with an evident increase of accomplishment, soon to yield to a more mechanical and less lively method of work. This influence of the impulse must first be eliminated from the "test-work," in order for the effect of the preceding fatigue (which comes from the principal work, that is, from the lesson) to appear in its purity. With great care, Kraepelin gives, on the ground of his eminent experience in conducting experiments on the factors of the work curve, all the precautions in order to get rid of these and other influences which, beside the fatigue whose amount is to be deduced, affect the quantity accomplished. He thereby enumerates just so many practical difficulties in making a decisive test of the sort mentioned.

In case we have, finally, accurately computed the amount in which fatigue has impaired the accomplishment of the "test-work," do we really possess in this number also an adequate

² Kraepelin, *Zur Uebermüdungsfrage*, 1892. Cf. *Psychologische Arbeiten*, I, S. 336-650.

measure of the fatigue? Should the decrease in so familiar and almost mechanical an activity as the addition of one place numbers be practically proportional to the expenditure of mental energy for a lesson in Latin, or in German composition, etc.? The "test-work" and the work which produced the fatigue would seem to be too dissimilar for that. On the other hand they must not be altogether similar, because otherwise the "stimulation" remaining after the principal work would make the "test-work" easier. Now to be sure fatigue is always general, and hence it must injure every sort of work. It does not follow, however, that every sort of work is suitable for "test-work." I recall the surprising discovery of the Würzburg teacher, Dr. Schmidt.³ In the time between twelve and one o'clock, a time of diminished mental energy, the home tasks of the children came out remarkably well if they consisted of exercises in copying and in computing. On the other hand, the same hour was decidedly unfavorable for German composition. In short, the daily depression does not show itself in the performance of computations. Hence this loses its trustworthiness as a measure of the degrees of fatigue.

Furthermore, Ebbinghaus' method of psychological measurement is not unobjectionable. The experiments of this careful investigator show beyond a doubt that "test-work" of a more mechanical character reveals the mental fatigue only very inaccurately. The fatigue is shown much better by the "combination test-work," that is, the filling in of words and syllables omitted from a printed text. But the step from this to the exact measurement of the fatigue brings serious difficulties. Kraepelin found these so great that he refrained entirely from tests of this sort, in which the quality of the performance comes into account or is even determinative. The influence of fatigue must certainly make itself felt in the reduction of quantity and quality of accomplishment in the "combination test-work;" but how is the decrease to be computed? "The importance of the errors and omissions is so various, even within the same experiment, that a simple counting is open to

³ Cf. the fourth article.

grave objections, whereas on the other hand a gradation of them could be made only quite arbitrarily."⁴ This difficulty of putting the number and kind of the errors into integers and fractions burdens not only the "combination test," it weighs upon all attempts to determine the degree of fatigue, which is something quantitative, from the qualitative deterioration which a test accomplishment shows after as compared with before the fatiguing lesson.

The psychological methods of measuring fatigue, which Kraepelin and Ebbinghaus have worked out, are our best and most advanced methods. They measure mental effort through mental performance, whether by the reduction of quantity or of quality. Beside these psychological methods there exist still physiological methods, which were developed earlier. These are the fatigue measurements in their baby shoes, as it were, and still more defective than the preceding. They make use of the crippling of the sensory and motor nerves by fatigue. Griesbach⁵ sets out from the observation that any fatigue of the attention, among other things, decreases the ability of the senses to make distinctions. He had noticed especially that the ability to distinguish two close point-like touch-impressions was smaller after mental effort than before it. Hence he thought that in the space-threshold (that is, the distance between two circular points which could just be distinguished by the sense of touch) he had found a measure of the degree of mental fatigue. This assumption has proved to be erroneous. The same variations in the fineness of discrimination in the sense of touch which Griesbach assumed to express the fatigue from mental work appeared in the control-experiments of the American

⁴ Kraepelin, "Ueber Ermüdungsmessungen," *Archiv für Psychologie*, I. Also according to Meumann, *Haus- und Schularbeit*, in the attempt to determine the size of the single errors and according to these to set up a scale of errors lies a particularly dangerous side of pedagogical experiment. For by a determination of the size of the errors, in case this determination was insufficiently established, one could create artificial results which would give no true representation of the facts (p. 16.)

⁵ Griesbach, *Energetik und Hygiene des Nervensystems in der Schule*, 1895.

Leuba⁶ on days of rest as well. Moreover, Griesbach's process is very much exposed to subjective unreliability. Upon stimulation with one circular point, the persons experimented upon frequently assert (from autosuggestion) that they perceive a double impression.

Other experimenters, especially Kemsies,⁷ set out from the fact that mental fatigue diminishes also the power of muscular accomplishment, and measured (by means of Mosso's ergographs) the height to which the middle finger of the right hand could raise certain weights (three to five kilograms) before and after mental work. But here too, as Bolton and Meumann bring out,⁸ we have no proportional to mental fatigue. Moreover, in this method we are met by insurmountable technical difficulties, which Kraepelin and Robert Müller have discovered.⁹

That is, all those kinds of work which are associated with noticeable or unnoticeable motor impulses (mechanical learning, reading in a whisper, computing) leave after their cessation a "psychomotor stimulation" which, in opposition to fatigue, at first renders easier every motor "test-work."¹⁰ On the other hand, other sorts of mental work, which require exclusive attention to sense impressions or to purely intellectual activities, exercise on that account an inhibiting influence on the carrying out of motor impulses, which along with fatigue makes the motor "test-work" more difficult. Such inhibition or stimulation must have passed away before the test by lifting can be begun. But then in the meantime the condition of fatigue has altered. More-

⁶ Leuba, "On the Validity of the Griesbach Method of Determining Fatigue." Cf. Germann, "The Invalidity of the Aesthesiometric Method as a Measure of Mental Fatigue," both articles in *The Psychological Review*, VI, 1899. Cf. Elliot und Meumann, "Kritik der Griesbachischen Methode," *Deutsche Schule*, 1901.

⁷ Kemsies, "Zur Frage der Uebermüdung," *Deutsche Medizinische Wochenschrift*, 1896.

⁸ Meumann, *loc. cit.*; Bolton, "Ermüdung, Raumsinn und Muskelleistung," *Kraepelins Psychologische Arbeiten*, IV, 175-234.

⁹ Kraepelin, *loc. cit.*; R. Müller, "Ueber Mossos Ergographen," *Philosophische Studien*, XVII, 1-29.

¹⁰ Bolton, *loc. cit.*, found the performance on the ergograph increased after adding for two hours.

over, the accomplishment of the motor "test-work" is made worse by no means only in consequence of the central fatigue, which is to be measured. Any fatigue of the muscles concerned also produces a like effect. The two components of the fatigue, the central and the peripheral, first have to be separated.

In short, wherever we look in the measurements of fatigue, a reliable result is everywhere denied us. None of the methods gives a trustworthy measurement of the fatigue arising from mental work; most of them never can give one. This takes away again the ground for any hope of approaching the problem of the plan of studies from this side. Again—for such hopes were according to our earlier consideration *a priori* illusory. We never have at our disposal comparable amounts of that which is the cause of the fatigue, the mental activity of the pupils in lessons in Latin, mathematics, religion, etc. The processes of instruction and learning differ from hour to hour. Every attempt to evaluate exactly the relative difficulty of the subjects contains, just on that account, an arbitrary factor. The *terminus ad quem*, for which we are seeking the measurement, remains unamenable to exact comparison. Now, furthermore, the same thing is true of the *terminus a quo*, namely, of the fatigue, from which we wanted to secure the measurement. For this also, the effect resulting from the occupation with the various matters of instruction, we lack any certain methods of measurement. Fiasco here, fiasco there. Neither the quantities of mental occupation, which we wish to measure, nor the quantities of fatigue, in which the work-equivalent of the former is held to be expressed, have as yet been precisely determined.